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EFFECT OF ALKALI TREATMENT ON TENSILE/CHEMICAL PROPERTIES AND DIELECTRIC STRENGTH OF BAMBOO AND GRASS FIBER REINFORCED POLYESTER COMPOSITES

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ABSTRACT

Bamboo and Grass fiber reinforced polyester hybrid composite material was fabricated using the rule of mixtures. The tensile and chemical properties of this composite were studied. The alkali treatment effect of the bamboo and grass fibers on these properties was also studied. The observation revealed that the increase in bamboo fiber content improved the tensile strength of the hybrid composite. These properties were found to be even better, when alkali treated bamboo/grass fibers were used in the hybrid composites. The chemical reactivity of bamboo and grass fibers reinforced polyester hybrid composites with acetic acid, hydrochloric acid, nitric acid, sodium hydroxide, carbon tetrachloride sodium carbonate, toluene, benzene and water was studied. The hybrid composite has shown better resistance to chemicals mentioned above. The dielectric strength of hybrid fiber reinforced composites was also investigated in the present work. A fiber-polymer interaction was also studied by scanning electron microscopy (SEM) on the cross-sections of fractured surfaces.

KEYWORDS: Bamboo Fibers, Grass Fibers, Chemical Resistance, Tensile Strength, Polyester & SEM

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Original Article

INTRODUCTION

Bamboo is extensively used as a valuable material from times immemorial (because of its low weight and high strength). In the present study, the bamboo and grass fiber reinforced polyester composites were developed and the effect of alkali treatment of bamboo/grass fibers on these properties was also studied. Many studies on the composites made from polyester matrix and natural fibers were reported in the literature [1]. Wong *et al* [2] investigated the fracture behavior of short bamboo fibre reinforced polyester composites and observed that the tensile strength of the composite increased with increase in bamboo fiber content. Satish Kumar *et al* [3] studied the tensile properties of the snake grass fiber and compared with the traditionally available natural fibers. Murali mohan Rao *et al* [4] investigated on the grass stalk fibers using retting and chemical (NaOH) extraction processes. And the fibers were incorporated in a polyester matrix and the tensile properties of fiber and composite were determined. Obuko et al [5] investigated on the development of Eco-composites using bamboo fibers and their basic mechanical properties and concluded that the steam explosion technique is essential to extract the bamboo fibers. Osorio *et al* [6] studied the morphological aspects of treated and untreated bamboo fiber composites and concluded that the treated fibers have more mechanical strengths then the untreated fiber composites. Varadharajulu et al [7] investigated that the chemical resistance of epoxy coated bamboo fibers have good strength

when alkali treated with polyester resin as a matrix. Subhash Mandal and Sarfaraz Alam [8] investigated on the Dynamic mechanical properties and morphology of short glass/bamboo fiber reinforced polyester composites by varying the volume fraction of the fiber and percentage of glass fiber replaced by bamboo fiber. Ashok Kumar et al [9] investigated on the Di-electric strength of hybrid fiber composites and concluded that the Di-electric strength increased with increase in weight fraction of fiber in the composite. Oushabi et al [10] studied the mechanical, thermal, chemical and morphological properties of date palm fibers and concluded that the alkali treatment improve the thermal resistance of date palm fibers due to the removal of the waxy layers and other impurities from the surface. The chemical resistance properties with varying fiber percent were also studied. The dielectric breakdown voltage was studied for each specimen at five different points and the average value was considered for analysis. The bonding between fibers and matrix were studied by using scanning electron microscope.

MATERIALS AND METHODS

The following subsections deal with the material and method used in the present study.

MATRIX

In the present work, unsaturated polyester resin was used as a matrix, Methyl ethyl ketone peroxide was used as a catalyst and cobalt naphthenate was used as an accelerator. The main feature of this resin is possessed of excellent mechanical and dynamic strength. It has a shelf life of two years; the bamboo fibers used in the present study were procured from the Tripura state in INDIA in dried form. To remove hemi cellulose and greasy nature of these fibers, these are soaked in 5% NaOH solution for 1 hr and then washed with water thoroughly. Grass fiber is procured from the Tungabhadra river of A.P. The same procedure is followed for both the fibers for alkali treatment.

PREPARATION OF THE COMPOSITE AND TEST SPECIMEN

For making the composite, molding box is prepared initially with a glass of size 200 mm x 200 mm x 3 mm. The mould is coated with a fine layer of aqueous solution of Poly Vinyl Alcohol (PVA) to act as a releasing agent. Next a thin coating of hard wax is coated over it and lastly, another fine layer of PVA was coated. Each coat was permitted to dry for 30min at room temperature. A 3mm thick plate was made from the blend of polyester, catalyst and accelerator. Then the molding box was loaded with the mixture of matrix, bamboo and grass fibers in random orientation with varying percentage and was placed in vacuum oven, which is maintained at 70^{o}c for three hours to complete the curing, after curing the plate was removed from the molding box with simple tapering and it was cut into samples for tensile tests with dimensions of 150 x 15 x $3mm^3$ as per ASTM-D 3039-76 specifications. The gauge length of the specimen was maintained at 100mm for this test. The specimen was tested by using INSTRON 3369 universal testing machine with the crosshead speed maintained at 5mm/min. The temperature and humidity of this test were maintained at 22^{0}C and 50% respectively. In each case 5 specimens were tested and the average value was noted. For comparison sake, the specimens of matrix material were also prepared in similar lines. The composite specimens were made as per ASTM-D149 to measure dielectric strength; fibers were reinforced with polyester along 120mm length for specimens having dimensions of 120mmx120mmx3mm. The dielectric breakdown voltage was determined at five points for each specimen and the average value calculated. The point selected was far enough so that there was no flashover. The test was carried out at a 50Hz frequency at room temperature. Digital micrometer with 0.001mm least count was used to find the thickness of the specimen at the breakdown point and the test was repeated for all specimens fabricated from different kinds of fibers.

A JEOL JSM 6400 Japan Scanning Electron Microscope (SEM) at 15kV accelerating voltage was equipped with energy dispersive spectroscopy (EDS) to find out the fiber matrix interfaces. Fractured specimen surfaces were gold coated and the fracture surface was observed using Scanning electron microscope. The fracture surfaces were gold coated with a thin film to increase the conductance.

RESULTS AND DISCUSSIONS

TENSILE LOAD MEASUREMENT

The tensile stress and Young's modulus was determined using INSTRON-3369 model UTM. The cross head speed for tensile test was maintained at 10mm/min. The temperature and humidity of this test were maintained at 18^{0}C and 25% respectively. In each case 5 samples were tested and average values were calculated.

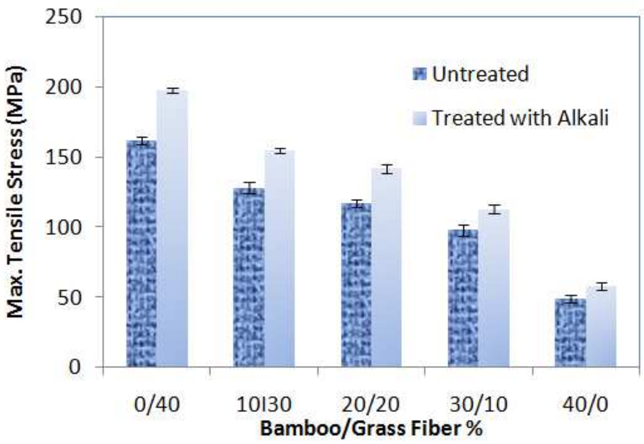

Figure 1: Variation of Maximum Tensile Stress at Yield with Ratio of Bamboo/ Grass Fibers Reinforced Polyester Composites for both Treated and Untreated Conditions

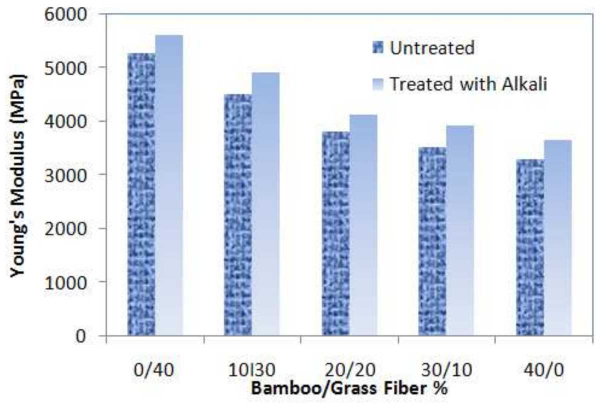

Figure 2: Variation of Young's Modulus with Ratio of Bamboo/ Grass Fibers Reinforced Polyester Composites

CHEMICAL RESISTANCE OF COMPOSITES

The chemical resistance of composites was studied as per ASTMD 543-87 method. For the chemical resistance test, the acids, namely concentrated hydrochloric acid (10%), Concentrated Nitric Acid (40%) and Glacial acetic Acid (8%); the alkalis namely aqueous solutions of sodium hydroxide (10%), Ammonium Hydroxide (10%) and Sodium Carbonate (20%) and the solvents- Benzene, Carbon Tetra chloride, Toluene and Water were selected. In each case, 10

Pre-weighted samples were dipped in the respective chemicals under study for 24Hrs, removed and immediately washed thoroughly with distilled water and dried by pressing them on both sides by filter papers. The final weight of samples and percentage of weight loss/gain was determined. The resistance test was repeated for 10 samples in each case and average values were calculated

Table 1: Percentage Change in Weight of Samples of Matrix and Composite after Performing Chemical Resistance Test

Chemical	Matrix	Composite
Hydrochloric Acid	+0.9525	+0.2459
Concentrated Nitric Acid	+0.1912	+0.2248
Glacial acetic Acid	+0.3821	+2.3542
Sodium hydroxide	-0.4125	-2.6548
Ammonium Hydroxide	-0.3851	-2.6584
Sodium Carbonate	+0.7626	-3.6541
Benzene	-1.2351	-1.3564
Carbon Tetra chloride	-1.1241	+4.2518
Toluene	-0.6543	-2.2648
Distilled Water	-1.3511	-1.5841

DI-ELECTRIC STRENGTH ANALYSIS

The variation of di-electric strength, break down voltage of Bamboo/Grass fiber composites are shown in Figure 3. Dielectric strength increases with an increase in the weight fraction of bamboo fiber in the composite. This is a very rare phenomena which are not observed in many natural fiber composites.

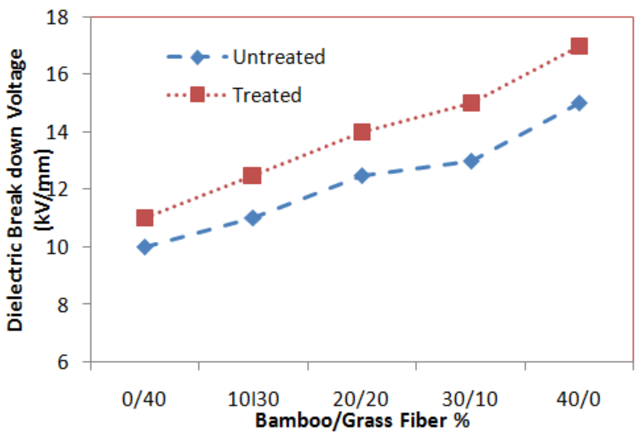

Figure 3: Variation of Di-Electric Strength as a Function of Bamboo/ Grass Fiber Reinforced Polyester Composites

MORPHOLOGY TEST ON CROSS SECTIONS OF FRACTURED SURFACES

To probe the bonding and reinforcement of the fiber with the matrix, the scanning electron micrographs of fractured surfaces of Bamboo/Grass reinforced polyester hybrid composites were examined. These micrographs were recorded at different magnifications and regions. The analysis of the micrographs of the composites prepared under different conditions is presented in the following sub sections.

UNTREATED BAMBOO/GRASS FIBER

The micrographs of fractured surfaces of untreated bamboo/ grass fibers are presented in fig 4a represents the

fractograms at two regions with magnification of 100x, fig 4b is the fractograms at these regions at a magnification of 200x. From all these micrographs it is evident that the fiber pullout is observed, indicating a poor bonding between the fibers. When the interfacial bonding is poor, the mechanical properties of the composites will be inferior. All the tensile strength of the Bamboo/Grass composites studied indicates that it is poor for these composites with untreated Bamboo/Grass fibers.

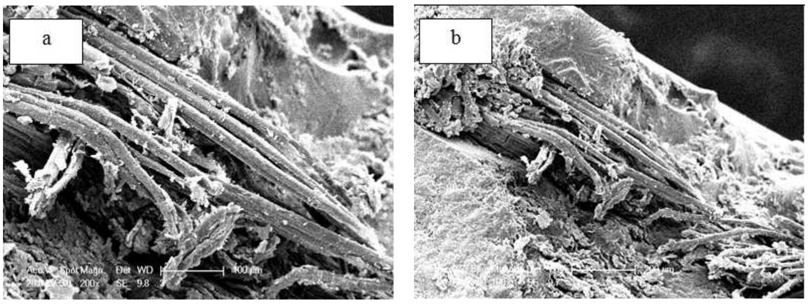

Figure 4: SEM Images of the Composite with Untreated Bamboo Fiber/Grass Fiber at different Magnifications

TREATED BAMBOO/GRASS FIBER

The fractographs of the composite that is alkali treated bamboo/Grass fibers are presented in the figure 5. These fractographs were recorded at two different regions at 100x (fig. 5a) and 200x (fig.5b) magnification. From these micrographs it is clearly evident that the surface of the fibers becomes rough on alkali treatment. The elimination of the hemi-cellulose from the surface of the fibers may be responsible for the roughening of the surface. Here the bonding is improved and the fiber pullout is reduced.

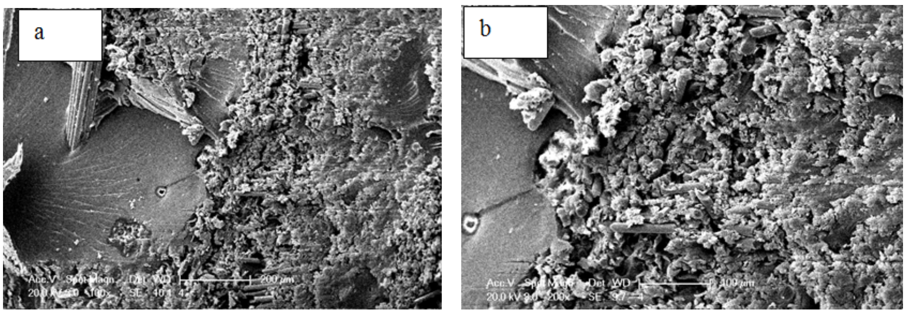

Figure 5: SEM Images of the Composite with Treated Bamboo Fiber/Grass Fiber at different Magnifications

CONCLUSIONS

The hybrid composites of bamboo/ Grass fiber reinforced polyester were prepared and their Mechanical, chemical resistance properties, dielectric properties and morphology were studied. The effect of the bamboo percentage of these properties was studied. These hybrid composites were found to exhibit good tensile and chemical resistance properties. The bonding between fibers and matrix was studied by SEM analysis. It was found that treated fibers have good bonding between matrix and fibers. The hybrid composites with bamboo fibers were found to possess higher tensile properties. The composites were found to be resistant to some acids, alkalis and solvents. The elimination of amorphous weak hemi cellulose components from the bamboo fibers may be responsible for this behavior. The dielectric strength of the composite increased with increase in wt% of bamboo.

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